Galaxy Cluster Masses

J.S. Arabadjis and M.W. Bautz

Massachusetts Institute of Technology

We present a spectral deprojection analysis of a sample of dynamically relaxed galaxy clusters. We test each cluster for the presence of multiphase gas and derive a temperature profile. We compare the resulting gravitating mass profiles to those derived from gravitational lensing experiments and to the results of numerical experiments. We find that the data are generally consistent with weak lensing measurements and CDM simulations. In some cases, however, the cluster core masses derived from X-ray observations differ from those determined from strong gravitational lensing.

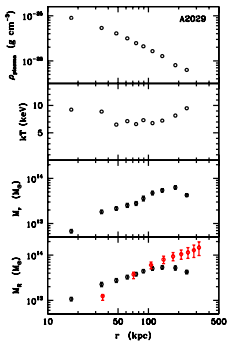
Sample:

We are currently working our way through the Chandra archive, analyzing all of the bright galaxy clusters for which there is evidence of a dynamically relaxed state – a single peak in the X-ray surface brightness, roughly circular isophotes, and the presence of a ‘‘cooling flow’’ temperature structure. From this sample we choose the five clusters for which a Navarro, Frenk and White (1997) profile fit produces the minimum residuals. We infer these clusters to be the most dynamically relaxed, and thus expect them to display the smallest discrepancies with gravitational lensing measurements. The five clusters in this sample are A2029 (z=0.0765), A1689 (z=0.181), A1835 (z=0.252), MS2137 (z=0.313) and MS1358 (z=0.328).

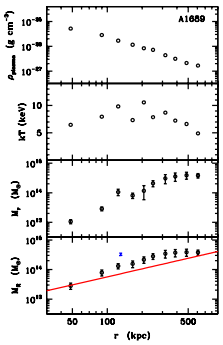
Procedure:

1. We perform a spectroscopic deprojection for both uni- and multiphase core plasma models (Arabadjis, Bautz & Garmire 2002).
2. We decide between the two models by running a series of Markov Chain Monte Carlo (MCMC) simulations. We adopt an MCMC threshold significance of 99% for the inclusion of a second (cool) core emission component (Arabadjis, Bautz & Arabadjis 2003).
3. We calculate a mass profile under the assumption of hydrostatic equilibrium, and reproject the result to compare with weak and strong gravitational lensing measurements.

Results:

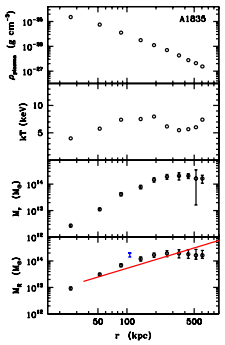


Weak lensing data from Menard Erben & Mellier (2003).



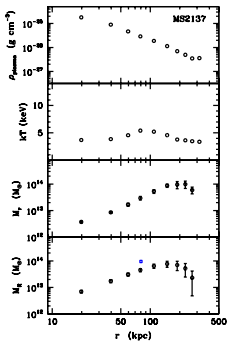
Isothermal sphere fit to the weak lensing data of King, Clowe & Schneider (2002).

Strong lensing measurement from Wu (2000).

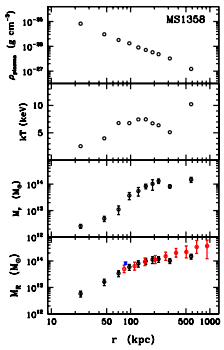


Isothermal sphere fit to the weak lensing data of Clowe Schneider (2002).

Strong lensing measurment from Allen et al. (2000).



Strong lensing measurment from Sand, Treu & Ellis (2002).



Weak lensing data from Hoekstra et al. (1998).

Strong lensing measurment from Allen et al. (1998) and Franx et al. (1997).

We find that, in general, our mass profiles are consistent with those derived from weak lensing analyses. However, in contrast to Allen (1998), we find significant disagreement between X-ray and strong lensing mass measurments in this sample of uber-relaxed clusters. It seems likely that sub-structure in the dark matter distribution is at least in part responsible for the discrepancies (Dahle et al 2002; Chen et al. 2003).

References:

Allen S.W. 1998, MNRAS, 296, 392
Arabadjis, J.S., Bautz, M.W. & Arabadjis, G. 2003, ApJ, submitted
Arabadjis, J.S., Bautz, M.W. & Garmire, G.P. 2002, ApJ, 572, 66
Chen, J., Kravtsov, A.V. & Keeton, C.R. 2003, ApJ, 92, 24
Clowe, D.I. & Schneider, P. 2002, A&A, 395, 385
Dahle, H., Kaiser, N., Irgens, R.J., Lilje, P.B. & Maddox, S. 2002, ApJ 139, 313
Franx, M., Illingworth, G.D., Kelson, D.D., van Dokkum, P.G. 1998, ApJ, 498, 195
Hoekstra, H., Franx, M. & Kuijken, K. 1998, ApJ, 504, 636
King, L.J., Clowe, D.I. & Schneider, P. 2002, A&A, 383, 118
Menard, B., Erben, T. & Mellier, Y. 2003, ASP Conf. Proc., Vol. 301, ed. S. Bowyer & C.-Y. Hwang (SF: ASP)
Navarro, J.F., Frenk, C.S. & White, S.D.M. 1997, ApJ, 490, 493
Sand, D.J., Treu, T. & Ellis, R.S. 2002, ApJ 574, L129
Wu, X.-P. 2000, MNRAS, 316, 299